

**Claims**

What is claimed is:

- 5           1. An image photographing apparatus comprising:
- a compensation lens group;
- a focusing driving part for fixing the compensation lens
- 10           group;
- a focus actuator transferring the focusing driving part to
- an optical axis for controlling the focus of the compensation lens
- group;
- a fixing part for supporting the focus actuator;
- a photographing element for photographing an image of an
- 15           object passing the compensation lens group; and
- a controlling part for controlling the focus actuator and
- the photographing element.
2. An image photographing apparatus comprising:
- 20           a compensation lens group;
- a focus actuator for controlling the focusing of the
- compensatio lens group;
- a first zoom driving part for supporting the focus actuator;
- 25           a displacement lens group;
- a second zoom driving part for supporting the displacement
- lens group;
- a zoom actuator for driving the first zoom driving part to
- move the compensation lens group along a first moving trajectory,
- 30           which is a zoom transition path, and driving the second zoom driving
- part to move the displacement lens group along a second moving
- trajectory, which is a path of a zoom transition path;
- a photographing element for photographing an image of an

object passing the compensation lens group and the displacement lens group; and

a controlling part for controlling the focus actuator, the zoom actuator and the photographing element.

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3. The image photographing apparatus as claimed in claim 1 or 2, the focus driving part comprising:

10 a first lens barrel combined with the compensation lens group in its interior and forming a first male screw on its outer circumference;

a second lens barrel combined with the focus actuator in its exterior and forming a first female screw, which is screw-combined with the first male screw on its inner  
15 circumference; and

a tool groove installed on the first lens barrel to insert and rotate the tool.

20 4. The image photographing apparatus as claimed in claim 1 or 2, the focus actuator comprising:

a driving coil wound on one side of the focus driving part or the first zoom driving part to be fixed, and receiving current from the controlling part; and

25 a magnet fixed to the other side of the focus driving part or the first zoom driving part, wherein the polarity of the magnet is divided so that a magnetic flux passes over the flat part of the driving coil.

30 5. The image photographing apparatus as claimed in claim 1 or 2, the focus actuator further comprising a restoration spring for restoring the focus driving part to the initial position.

6. The image photographing apparatus as claimed in claim 4, further comprising a yoke between the magnet and the focus driving part for increasing efficiency of the magnetic field generated by the magnet.

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7. The image photographing apparatus as claimed in claim 4, further comprising a yoke between the magnet and the first zoom driving part for increasing efficiency of the magnetic field generated by the magnet.

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8. The image photographing apparatus as claimed in claim 1 or 2, the focus actuator comprising:

a driving part for receiving a power source from the controlling part to generate a dynamic force moving along the direction orthogonal to the optical axis; and

a cam part for receiving the dynamic force of the driving part to switch the dynamic force transferring the focus driving part in the direction of the optical axis.

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9. The image photographing apparatus as claimed in claim 8, the driving part comprising:

a motor rotating by the power source supplied by the controlling part;

a spur gear combined with a center shaft of the motor to be rotated; and

a rotor forming a gear tooth combined with the spur gear and rotating by receiving the power source supplied by the controlling part.

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10. The image photographing apparatus as claimed in claim 8, the driving part comprising:

a motor rotating by the power source supplied by the controlling part;

a lead screw combined with a rotation shaft of the motor;

5 and

a screw holder combined with the lead screw to move along the direction orthogonal to the optical axis by rotation of the lead screw.

10 11. The image photographing apparatus as claimed in claim 8, the cam part comprising an inclined surface formed on the driving part for ascending the focus driving part in the direction of the optical axis, wherein the focus driving part forms a prominence contacting to the inclined surface.

15 12. The image photographing apparatus as claimed in claim 1 or 2, the focus actuator comprising a piezoelectric element 4300 installed between the compensation lens group and the fixing part or between the compensation lens group and the first zoom driving part, and receiving the current from the controlling part to drive the compensation lens group in the direction of the optical axis.

20 13. The image photographing apparatus as claimed in claim 1, the focus actuator comprising a suspension member supported between a fixing part and the focus driving part so that the focus driving part is controlled to be moved along the direction of the optical axis direction to limit the driving of the focus driving part in the direction excluding the driving direction, thereby guiding the focus driving part to be accurately driven along the

25 30 direction of the optical axis.

14. The image photographing apparatus as claimed in claim 13, the focus actuator comprising:

a magnet fixed to the fixing part or the focus driving part;  
a driving coil fixed to the side of the fixing part or the  
focus driving part, where the magnet is not fixed, to be exposed  
to the magnetic field of the magnet, and, at the time of applying  
the current of the controlling part, wound to generate a force  
to drive the focus driving part in the direction of the optical  
axis by receiving the magnetic flux of the magnet; and

a magnetic substance fixed to the side where the driving  
coil is fixed, and moving the focus driving part by force attracted  
to the magnetic force of the magnet to fix the focus driving part  
to a predetermined position.

15. The image photographing apparatus as claimed in claim  
13, the suspension member comprising a plate spring or a wire spring.

16. The image photographing apparatus as claimed in claim  
15, the plate spring comprising:

an elastic transformed part transformed in the direction  
of the optical axis by narrowing the width between the fixing part  
and the focus driving part;

a plurality of first holes; and

first and second bosses inserted into a plurality of the  
first holes to fix the suspension member to the first zoom driving  
part and the focus driving part.

17. The image photographing apparatus as claimed in claim  
1, the focus actuator further comprising guide means for guiding  
the focus driving part to be driven in the direction of the optical  
axis.

18. The image photographing apparatus as claimed in claim  
17, the guide means comprising:

a slide prominence formed on one side of the focus driving part in the direction of the optical axis; and

5 a slide groove formed on the side where the slide prominence of the focus driving part is not formed for guiding the slide prominence to be moved in the direction of the optical axis.

19. The image photographing apparatus as claimed in claim 1, the guide means comprising a guide shaft slidably combined to  
10 a guide hole formed on the focus driving means.

20. The image photographing apparatus as claimed in claim 19, the guide means further comprising three or more guide parts formed on the fixing part in the direction of the optical axis  
15 to guide the outer circumferential surface of the focus driving part in the direction of the optical axis.

21. The image photographing apparatus as claimed in claim 19, the controlling part comprising:

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a controlling signal generating part for generating a low frequency amplitude modulation control signal for preventing a friction force for an initial predetermined driving time for supplying current to the driving coil, and for generating a high  
25 frequency amplitude modulation control signal after the initial predetermined driving time; and

a pulse width modulation signal outputting part for outputting the low frequency amplitude modulation control signal generated by the controlling signal generating part and a pulse  
30 width modulating signal outputting part having a lower frequency section and a high frequency section which switch on/off according to the high frequency amplitude modulation control signal to drive the driving coil of the focus actuator.

22. The image photographing apparatus as claimed in claim 21, characterized in that the low frequency amplitude modulation controlling signal and the high low frequency amplitude modulation controlling signal have the identical duty ratio.

23. The image photographing apparatus as claimed in claim 22, a pulse width modulation signal outputting part comprising:

a transistor having an emitter connected to the ground, a base for receiving the low frequency amplitude modulation control signal and the high frequency amplitude modulation control signal generated by the controlling signal generating part, and a collector connected to a driving element; and

a resistor connected between the transistor and the base; and

a diode connected between the collector of the transistor and the power source.

24. The image photographing apparatus as claimed in claim 1 or 2, the focus actuator comprising:

a compensation driving part installed between the compensation lens group and the focus driving part to drive the compensation lens group;

a compensating suspension member connected between the compensation driving part and the focus driving part to fix the compensation lens group to the focus driving part thereby become movable into the direction orthogonal to the optical axis of the compensation lens group;

a compensation actuator supported between the compensation driving part and the focus driving part to drive the compensation driving part in the direction orthogonal to the optical axis;

a displacement sensor installed on one side of the focus driving part for sensing the movement of the focus driving part in the direction orthogonal to the optical axis due to the hand trembling of the user; and

5 a servo controller driving the compensating actuator according to information of the displacement sensor to restore the focus driving part to the original state.

25. The image photographing apparatus as claimed in claim  
10 24, the compensation suspension member comprising a wire spring or a plate spring.

26. The image photographing apparatus as claimed in claim  
24, the compensation actuator comprising one of a voice coil motor,  
15 a piezoelectric element and a ultrasonic motor.

27. The image photographing apparatus as claimed in claim  
4, the focus actuator further comprising an initial position fixing  
part for fixing the focus driving part to an initial position by  
20 a predetermined braking power.

28. The image photographing apparatus as claimed in claim  
27, the initial position fixing part comprising a first magnetic  
25 substance fixed to the side, where the magnet of the focus driving part is fixed, not to be exposed to the range of the magnetic line of force on the side, where the magnet of the focus driving part is not fixed, and attracts the magnet in order to fix the focus driving part to the initial position.

29. The image photographing apparatus as claimed in claim  
4, the focus actuator further comprising a specific magnification  
position fixing part for moving the focus driving part to a specific



position so that the object image of the compensation lens group is projected with a specific magnification.

30. The image photographing apparatus as claimed in claim  
5 29, the specific magnification position comprising a second magnetic substance fixed to the side, where the magnet of the focus driving part is not fixed, not to be exposed to the range of the magnetic line of force, and attracts the magnet to fix the focus driving part to the initial position, in order to fix the focus  
10 driving part to a specific magnification position.

31. The image photographing apparatus as claimed in claim 2, a second zoom driving part comprising:

15 a third lens barrel combined with the displacement lens group in its interior and forming a second male screw on its outer circumference; and

a fourth lens barrel combined with the focus actuator in its exterior and forming a second female screw, which is  
20 screw-combined with the first male screw on its inner circumference.

32. The image photographing apparatus as claimed in claim 2, the zoom actuator comprising:

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an actuation source;

a first zoom driving member for driving the first zoom driving part to move a compensation lens group along a first moving transjectory, which is a zoom transition path;

30 a second zoom driving member for receiving a dynamic force from the actuation source and driving the second zoom driving part to move the displacement lens group along a second moving trajectory, which is a zoom transition path; and

restoration means for restoring the first zoom driving part and the second zoom driving part to the original state.

33. The image photographing apparatus as claimed in claim 5 32, the actuation source comprising:

a rotation driving part for generating a rotatory force by control of the controlling part; and

10 a rotor for receiving a dynamic force of the rotation driving part to be rotated.

34. The image photographing apparatus as claimed in claim 15 33, the first zoom driving member comprising a first inclined surface ascending the first zoom driving part by rotation of the rotor to move the compensation lens group along the first moving trajectory, which is the zoom transition path.

35. The image photographing apparatus as claimed in claim 20 33, the second zoom driving member comprising a second inclined surface ascending the second zoom driving part by rotation of the rotor to move the displacement lens group along the second moving trajectory, which is the zoom transition path.

36. The image photographing apparatus as claimed in claim 25 32 or 33, the actuation source comprising:

a motor for receiving a power source from the controlling part to be rotated;

30 a spur gear combined with a center shaft of the motor to be rotated; and

a rotor forming a gear tooth combined with the spur gear.

37. The image photographing apparatus as claimed in claim

32 or 33, the actuation source comprising:

a motor for receiving a power source from the controlling part to be rotated;

5 a lead screw combined with the rotation shaft of the motor; and

a screw holder combined with the lead screw to move in the direction orthogonal to the optical axis by rotation of the lead screw.

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38. The image photographing apparatus as claimed in claim 37, the screw holder comprising a guide shaft for guiding the movement of the screw holder.

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39. The image photographing apparatus as claimed in claim 37, the first zoom driving member comprising a third inclined surface formed on the screw holder and ascending the first zoom driving part in the direction of the optical axis when the screw holder moves in the direction orthogonal to the optical axis in order to move the compensation lens group along the first moving trajectory, which is the zoom transition path.

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40. The image photographing apparatus as claimed in claim 37, the second zoom driving member comprising a fourth inclined surface formed on the screw holder and ascending the second zoom driving part in the direction of the optical axis when the screw holder moves in the direction orthogonal to the optical axis in order to move the second zoom lens group along the second moving trajectory, which is the zoom transition path.

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41. The image photographing apparatus as claimed in claim 2, the zoom actuator comprises:

a stator for receiving a power source from the controlling part and having coils to generate a magnetic field having first and second polarities, which are divided into a plurality of sections and which are alternated;

5 two ring-shaped magnets, which are integrally assembled and in which its polarity is divided into a first polarity and a second polarity, so as to be exposed to the magnetic field generated from the coils,;

10 an assembly member for assembling the two ring-shaped magnets to have a 90 degree of phase;

an upper part of the rotator for receiving a rotation force when current is applied to the first coil;

a lower part of the rotator for receiving a rotation force when current is applied to the second coil;

15 a rotator assembling member for integrally assembling the two rotators to have 90 degree of phase difference with each other;

a pair of a first rotator and a first stator for driving the compensation driving part;

20 a first lens barrel for fixing the compensation lens group; and

a first cam part for converting the rotation force of the first rotator to a feed force in the direction of an optical axis to and transferring it to the first lens barrel.

25 42. The image photographing apparatus as claimed in claim 41, the stator comprising:

30 a magnetic substance formed by laminating two members, and having a plurality of upper cores, which are respectively correspond to the identical first polarity divided from the first and the second magnets;

a magnetic substance having a plurality of lower cores, which are respectively correspond to the identical second polarity

divided from the first magnet and which are respectively inserted into the upper cores; and

a first driving coil wound on an outer circumference of a combined substance of the upper core with the lower core.

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43. The image photographing apparatus as claimed in claim 42, the first rotator comprising a first rotation barrel forming a first trajectory groove consistent with the first moving trajectory, and the first cam part comprising:

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a first cam shaft fixed to the first lens barrel, and inserted into the first trajectory groove; and

a first guide barrel forming a first slot for guiding the first cam shaft such that it only moves in the direction of the optical axis.

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44. The image photographing apparatus as claimed in claim 42, the second rotator comprising:

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a third lens barrel for fixing the zoom lens group; and  
a second cam part for converting the rotation force of the second rotator to feed force in the direction of the optical axis to transfer it to the third lens barrel,

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and second rotator further comprising:

a second rotation barrel fixed by the second magnet and forming a second trajectory groove consistent with the second moving trajectory, which is the zoom transition path.

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45. The image photographing apparatus as claimed in claim 42, the first cam part comprising:

a first magnet; and

a cam barrel formed on a cross-section of the first rotation barrel and forming a cam surface for moving the first lens barrel along the first moving trajectory;

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and the first cam part comprising:

a cam barrel formed on a cross-section of the third rotation barrel and forming a cam surface for moving the first lens barrel along the first moving trajectory; and

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an elastic member generating a predetermined elasticity for pushing the first lens barrel to the cam barrel.

46. The image photographing apparatus as claimed in claim 45, characterized in that the cam surface is formed as a double row in the symmetrical position, and two points of the third lens barrel are respectively contact to the cam surface.

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47. The image photographing apparatus as claimed in claim 41, the second zoom actuator comprising:

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a second stator for receiving a power source from the controlling part, and having a second coil for generating a magnetic field having first and second polarities which are divided into a plurality of sections and which are respectively alternated;

25

a second rotator having a second magnet in which first and second polarities are divided to be exposed to each divided magnetic field generated from the second coil, and performing a rotational motion at the time of applying current to the second coil;

30

a second lens barrel for fixing the compensation lens group; and

a second cam part for converting the rotational force of the first rotator to a feed force in the direction of the optical

axis and transferring it to the second lens barrel.

48. The image photographing apparatus as claimed in claim 47, the second stator comprising:

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a third magnetic substance having a plurality of third cores respectively corresponding to the same first polarity divided from the second magnet;

10 a fourth magnetic substance having a plurality of fourth cores respectively corresponding to the same second polarity divided from the second magnet and respectively inserted into the third cores; and

15 the second coil wound around the outer circumference of the third cores and the fourth cores while the fourth cores are combined between each third core.

49. The image photographing apparatus as claimed in claim 47, the second rotator comprising:

20 a second magnet; and

a second rotation barrel forming a second trajectory groove consistent with the second moving trajectory,

said second cam part comprises:

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a second cam shaft fixed to the fourth lens barrel and inserted into the second trajectory groove; and

30 a second guide barrel forming a second slot for guiding the second cam shaft such that it only moves in the direction of the optical axis.

50. An image photographing apparatus comprising:

a focus lens group;

a focus actuator for adjusting the focusing of the focusing lens group;

a fixing part for supporting the focus actuator;

a compensation lens group;

a third zoom driving part for supporting the compensation lens group;

a displacement lens group;

a second zoom driving part for supporting the displacement lens group;

a zoom actuator for driving the third zoom driving part to move the compensation lens group along the first moving trajectory, and for driving the second zoom driving part to move the displacement lens group along the second moving trajectory;

a photographing element for photographing an object image passing the compensation lens group and the displacement lens group; and

a controlling part for controlling the focus actuator, the zoom actuator and the photographing element.

51. The image photographing apparatus as claimed in claim 5, further comprising the focus driving part between the focusing lens group and the focus actuator, wherein the focus driving part comprises a first lens barrel combined with the compensation lens group in its interior and forming a first male screw on its outer circumference; and a second lens barrel combined with the focus actuator in its exterior and forming a first female screw, which is screw-combined with the first male screw on its inner circumference.

52. The image photographing apparatus as claimed in claim 52, the focus actuator comprising:



a driving coil wound on one side of the focus driving part or the first zoom driving part to be fixed, and receiving current from the controlling part; and

5 a magnet fixed to one side of the focus driving part or the first zoom driving part, wherein the polarity of the magnet is divided so that the magnetic flux passes over the flat part of the driving coil.

10 53. The image photographing apparatus as claimed in claim 52, the focus actuator comprising a second restoration spring for restoring the focus driving part to the initial position.

15 54. The image photographing apparatus as claimed in claim 52, further comprising a yoke on a side of the magnet for circulating the magnetic flux.

20 55. The image photographing apparatus as claimed in claim 50, the focus actuator comprising a piezoelectric element installed between the compensation lens group and the first zoom driving part, and receiving the current from the controlling part to drive the first zoom driving part in the direction of the optical axis.

25 56. The image photographing apparatus as claimed in claim 50, the second zoom driving part comprising:

a fourth lens barrel combined with the displacement lens group in its interior and forming a second male screw on its outer circumference;

30 a fourth lens barrel forming a second female screw, which is screw-combined with the second male screw on its inner circumference.

57. The image photographing apparatus as claimed in claim 50, the third zoom driving part comprising:

5 a fifth lens barrel combined with the compensation lens group in its interior and forming a third male screw on its outer circumference; and

a sixth lens barrel forming a third female screw which is screw-combined with the third male screw.

10 58. The image photographing apparatus as claimed in claim 50, the zoom actuator comprising:

an actuation source;

15 a first zoom driving member for receiving a dynamic force from the actuation source and driving the first zoom driving part to move a compensation lens group along a first moving trajectory, which is the zoom transition path; and

20 a second zoom driving member for receiving a dynamic force from the actuation source and driving the second zoom driving part to move the displacement lens group along a second moving trajectory, which is the zoom transition path.

25 59. The image photographing apparatus as claimed in claim 50, comprising first restoration means for restoring the first zoom driving part and the second zoom driving part to the original state.

60. The image photographing apparatus as claimed in claim 58, the actuation source comprising:

30 a rotation driving part for generating a rotatory force by control of the controlling part; and

a rotor for receiving a dynamic force of the rotation driving

part to be rotated.

61. The image photographing apparatus as claimed in claim 60, the first zoom driving member comprising a first inclined surface ascending the first zoom driving part by rotation of the rotor to move the compensation lens group along the second moving trajectory, which is the zoom transition path, and the second zoom driving member comprising a second inclined surface ascending the second zoom driving part by rotation of the rotor to move the displacement lens group along the second moving trajectory, which is the zoom transition path.

62. The image photographing apparatus as claimed in claim 60, the actuation source comprising:

a yoke;

a coil wound on the yoke and receiving a power source from the controlling part for magnetizing the yoke; and

a rotor rotatably installed on the yoke, thereby facing the yoke, and consisting of a magnet rotating according to the direction to which the current applied to the coil.

63. The image photographing apparatus as claimed in claim 60, the actuation source comprising:

a motor for receiving a power source from the controlling part to be rotated;

a rotor forming a spur gear combined with the spur gear.

64. The image photographing apparatus as claimed in claim 60, the actuation source comprising:

a motor for receiving a power source from the controlling

part to be rotated;

a lead screw combined with the rotation shaft of the motor;  
and

5 a screw holder combined with the lead screw to move in the  
direction orthogonal to the optical axis by rotation of the lead  
screw.

10 65. The image photographing apparatus as claimed in claim  
64, the first zoom driving member comprising a third inclined  
surface formed on the screw holder and ascending the first zoom  
driving part in the direction of the optical axis when the screw  
holder moves in the direction orthogonal to the optical axis in  
order to move the compensation lens group along the second moving  
trajectory, which is the zoom transition path, and the second zoom  
15 driving member comprising a fourth inclined surface formed on the  
screw holder and ascending the second zoom driving part in the  
direction of the optical axis when the screw holder moves in the  
direction orthogonal to the optical axis in order to move the  
displacement lens group along the second moving trajectory, which  
20 is the zoom transition path

25 66. The image photographing apparatus as claimed in claim  
4, the focus actuator further comprising a plurality of iron plate  
attached to a predetermined position between the magnet and the  
yoke, thereby directing the current respectively applied to the  
driving coil to the end direction.

30 67. The image photographing apparatus as claimed in claim  
1, comprising a brake device fixed to the focus driving part for  
controlling the driving of the focus driving part.

68. The image photographing apparatus as claimed in claim  
67, the brake device comprising:

a rotation shaft installed on the focus driving part;  
a brake driving part rotatably installed on the rotation shaft;

5 a spring for pushing the brake driving part in a direction;  
a permanent magnet installed on a predetermined position of the brake driving part; and

a driving coil installed adjacent to the brake driving part in a predetermined position of the first zoom driving part.

10 69. The image photographing apparatus as claimed in claim 68, the brake device characterized in that:

15 when the current is not applied to the driving coil, the brake driving part maintaining the contacting state to the focus driving part, thereby fixing the focus driving part by friction force between the brake driving part and the focus driving part; and

20 when the current is applied to the driving coil, the brake driving part is attracted to the driving coil direction by cooperation of the magnetic force generated by the driving coil with the permanent magnet installed on the brake driving part so that the contact of the brake driving part to the focus driving part is cut, thereby freely moving the focus driving part.

25 70. The image photographing apparatus as claimed in claim 2 or 50, further comprising a brake device fixed to the second zoom driving part or one of the second driving part to control the driving of the second zoom driving part or the third zoom driving part.

30 71. The image photographing apparatus as claimed in claim 70, the brake device comprising:

a rotation shaft installed on the second zoom driving part or the third driving part;

a brake driving part rotatably installed on the rotation shaft;

a spring for pushing the brake driving part in a direction;

a permanent magnet installed on a predetermined position of the brake driving part; and

a driving coil installed adjacent to the brake driving part in a predetermined position of the second zoom driving part or the third zoom driving part.

72. The image photographing apparatus as claimed in claim 71, the brake device characterized in that:

when the current is not applied to the driving coil, the brake driving part maintaining the contacting state to the second zoom driving part or the third zoom driving part, thereby fixing the second zoom driving part or the third zoom driving part by friction force between the brake driving part and the second zoom driving part or the third zoom driving part; and

when the current is applied to the driving coil, the brake driving part is attracted to the driving coil direction by cooperation of the magnetic force generated by the driving coil with the permanent magnet installed on the brake driving part so that the contact of the brake driving part to the second zoom driving part or the third zoom driving part is cut, thereby freely moving the the second zoom driving part or the third zoom driving part.

73. The image photographing apparatus as claimed in claim 1 or 2, further comprising a shutter device installed between the compensation lens group and the focus driving part, or installed between the compensation lens group and the first zoom driving,

thereby controlling the light quantity.

74. The image photographing apparatus as claimed in claim 73, the shutter device comprising:

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a base fixed to the first zoom driving part and having a light through-hole passing light through the compensation lens group;

a shutter part axially supported by the base;

10 a piezo ceramic driving part for driving the shutter part by receiving a power source.

75. The image photographing apparatus as claimed in claim 73, the shutter device comprising:

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a shutter plate forming a rotation hole which is rotatably combined with a hinge shaft formed on the base, and which opens and closes the light through-hole by rotational motion.

20 76. The image photographing apparatus as claimed in claim 75, the shutter plate is characterized in being installed on the opposite position based on the light through-hole to simultaneously open and close the light through-hole at both sides by the operation of the piezo ceramic driving part.

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77. The image photographing apparatus as claimed in claim 76, said each shutter plate is characterized in being axially supported in the base and forms a cam hole combined with a driving shaft of the piezo ceramic driving part, so that when the driving shaft performs a straight line motion, each shutter plate performs  
30 a rotational motion to open and close the light through-hole.

78. The image photographing apparatus as claimed in one of

claims 74-77, the controlling part is characterized in functioning as an iris which closes narrow limits of the light through-hole by applying a small amount of the power source to the piezo ceramic driving part to drive the shutter part within narrow limits, and  
5 the controlling part functions as a shutter which closes the hole light through-hole by applying a large amount of the power source to the piezo ceramic driving part to drive a large range of the shutter part.